# ABSTRACTS FROM ASTRONOMICAL PUBLICATIONS.

In accordance with a recent arrangement the members of the scientific staff of the Lick Observatory hold meetings once per week, as an observatory duty, to report upon and discuss the more important articles appearing in the journals of astronomy, the important new books on astronomical subjects, or subjects of current and special interest in the observatory's work. It has been suggested that abstracts of the reports would be of interest to the readers of these *Publications*, and the Publication Committee has acted favorably upon the suggestion.

It is intended to preserve the qualities of abstracts as far as possible, and to restrict published criticisms, favorable or unfavorable, to a minimum.

## Radial Velocities and the Objective Prism.

Stellar spectroscopy has two main problems, the interpretation of the qualitative and the quantitative results obtainable from spectrographic photographs. From the former flow, or may be derived in the future, classification of stellar spectra, and data on physical conditions and transformations of the stars. From the latter proceed radial velocities, the Sun's velocity through space, the relative amounts of velocity pertaining to the different spectral classes of stars, confirmation of star-streaming and associated data, and orbits of spectroscopic binaries. The qualitative results are more easily obtainable than the quantitative, since much can be derived from objective prism photographs. Quantitative results depend upon comparison spectra, which have thus far been satisfactorily obtained only with slit spectroscopes. The slit spectroscope is excessively inefficient and requires very much longer exposures than the objective prism apparatus. Three-prism spectroscopes are impracticable beyond the fifth magnitude and two prisms beyond the seventh, while one prism does not give accurate velocities. The quantitative problem therefore needs the development of new methods for stars beyond the fifth magnitude.

A discussion of this problem by Dr. Schlesinger has recently appeared in the *Proceedings of the American Philosophical Society*, **3**, 1913, and the following points are taken from the article.

Extension of radial velocity work to stars of sixth, seventh, eighth, and ninth magnitudes is much desired. Larger telescopes with slit spectrographs will gain very little, since 12-inch telescopes have been able to do certain work almost as efficiently as the largest telescopes. The photographic plate in a slit

spectrograph receives only one or two per cent of the light that falls upon the objective of the telescope, while with the objective prism, the plate may receive as much as 25 per cent. Furthermore the slit spectrograph secures only one spectrum at a time, while the objective prism may secure several on the same plate. But the lack of means of placing satisfactory comparison spectra upon objective-prism plates prevents the determination of velocities from such plates. Several methods of securing objective-prism spectra in such a way as to determine velocity have been suggested, but none developed. They are briefly explained as follows:—

A quarter century ago PICKERING suggested, in connection with experimental work for the Draper Memorial, that radial velocities might be determined if some absorptive medium which would produce one or more narrow and sharp lines could be placed in the objective-prism telescope. He did not find a satisfactory absorbing medium, but R. W. WOOD has since proposed neodymium chloride, which gives a fairly sharp and narrow line at wave-length 4272. Experiments are being made with it, but its accuracy is not more than that represented by a probable error of ten kilometers. The method is applicable only to stars of early type, since with solar and later types the neodymium lines would be involved with the stellar lines.

PICKERING has also suggested the method of reversing the objective prism, which is set with its edge parallel to the equator. Two adjacent stars would be selected for the determination of their relative velocity, and would be photographed in both positions of the prism. The result would be two pairs of spectra, one with violet ends north and one with violet ends south. A difference of radial velocity in these stars would produce a difference of distance between identical lines in the two spectra such that half the difference of the measured distances would be a measure of the relative radial velocity. In other words, the K line of a star approaching the Sun would be shifted toward the violet,—that is, first toward the north, then toward the south an amount more or less than the K line in the other spectrum according as the velocity is more or less than that of the other star. The reversing of the prism could be effected by reversing the telescope about the polar axis

and one of the plates could be exposed with film behind the glass so that in measurement the two plates could be placed film to film for differential measurement. STEWART has suggested the use of two objectives with oppositely placed prisms adjusted to place the direct and the reversed spectra side by side on the same plate. COMSTOCK suggested that the two prisms be placed over a single objective, with their refracting edges meeting on a diameter of the objective. SCHLESINGER has suggested two independent objective prism cameras under constant temperature control. There are serious difficulties to be dealt with; for instance, in case of independent exposures, differential refraction, and dissimilar guiding; also the distortion of the field due to the prism or the prismatic astigmatism which curves the spectra in one direction and unequally lengthens or shortens them in the other. These distortions are least in COMSTOCK's design and practically absent in STEWART's design with the spectra at the centers of prisms, objectives, and plate. Patience, perseverance, and skill would probably overcome the difficulties.

A further method is made possible by the following circumstance: In prismatic spectra velocity displacements are greater in the violet than in the red region. The spectra are therefore shortened for receding stars and lengthened for approaching stars. The possibility of determining velocities from the change of length of spectrum caused by velocity occurred also to PICKERING, who remarks, on page xxi of volume **26**, of the *Annals of Harvard College Observatory:* "The change in length of the spectrum due to the motion of the star would only amount to about one sixth" of the displacement of the lines due to motion, "and could not readily be distinguished from a variation in temperature of the prism." This suggestion, however, may now lead to valuable results because of the recent developments in the use of photographic plates. Since the staining of plates with certain dyes has been found to render them sensitive to yellow and red wave-lengths, a greater length of spectrum and therefore a greater amount of change of length of spectrum are available. Formerly only the violet from $\lambda$ 3800 to $\lambda$ 4800 could be photographed; but now the spectrum from $\lambda$ 3800 to $\lambda$ 6500 can be obtained. The ordinary objective,

however, does not bring to focus all of this region. An objective or correcting lens could be made to bring to the same focus the region round about $\lambda$ 4000 and that round about $\lambda$ 6000. A great difficulty in objective-prism work is the displacements caused by change of temperature, but a constant temperature case like that used with slit spectrographs could be applied to the entire objective-prism instrument. The prism would have to be calibrated by stars whose velocities have been determined with slit spectrographs. The spectrum of a star of known velocity could be placed beside the spectrum of the star of unknown velocity. The difference of length of the two spectra could then be measured and the corresponding amount of velocity added to the known velocity.

It might eventually be desired to increase the light-gathering power of the apparatus without increasing the size of the objective prism. This might be accomplished by replacing the secondary of a Cassegrain reflector by a convex paraboloid or by placing a diverging lens near the focus of a refractor, in each case to obtain a condensed beam of parallel light of the size of the objective-prism camera.

The prospect of obtaining radial velocities by means of the objective prism seems good enough to warrant a trial of all three of the methods above mentioned. The use of the absorbing medium would probably lead to immediate results, but with only a moderate degree of precision. The method depending upon the length of spectrum might be developed to give accurate results.

G. F. PADDOCK.

November, 1913.

## DISCUSSION OF THE REVISED HARVARD PHOTOMETRY.

Number IV of Volume LXIV of the *Annals of the Harvard College Observatory* is devoted to a thorough discussion of the errors contained in the numerous photometric catalogs upon which the Revised Harvard Photometry (H. A., **50**) is based.

The method adopted was that of grouping the stars in the R. H. P. according to their position in the sky, their magnitude and their spectrum. The sky was divided in forty-eight sections exactly equal in area, for position; the stars were to be divided into six groups according to magnitude, and also into

six groups according to their spectra. The 9,110 stars were thus divided into a possible 1,728 groups. "Some of these groups do not contain any stars. The number of stars in each group and the algebraic mean of the sixteen residuals given in the Revised Harvard Photometry were next taken."

The major portion of the present publication is composed of condensed tables exhibiting these residuals and the conclusions that are to be drawn from them as to the accuracy of the various photometric catalogs. The conclusion is:—

> "The observations contained in the various meridian photometer catalogues, although extending over a period of twenty-seven years, and made with different instruments, by different observers, and in different places, agree closely as regards scale, the differences amounting to only a few hundredths of a magnitude. . . . The agreement as regards color is also good, for nearly all the catalogues."

But the data in these tables can also be used to study the distribution of the stars of different classes of spectra, and it is this study that yields the most interesting and important conclusion contained in the paper. It may best be stated in Professor PICKERING's own words:—

> "The theoretical value of the coefficient, *a*, which connects the logarithm of the number of stars with the magnitude, is 0.60. The observed value of this constant from all the bright stars is 0.51, from which the existence of an absorbing medium in space has been inferred. Grouping the stars according to their spectra, we find that for stars of Classes A to F, from the fourth to the sixth magnitude, the coefficient is very nearly 0.60. Great doubt is thus thrown on the existence of an absorbing medium. The coefficient far stars of Classes G, K, and M is about 0.51, while for stars of Class B it is much smaller, 0.42, indicating that there are few faint stars of this class. Except in the case of Class B, there is no distinct evidence that there are more stars on one side of the Sun than on the other."

R. G. AITKEN.

October, 1913.

DIE VERÄNDERLICHEN STERNE: ERSTER BAND; GESCHICHTLICH-TECHNISCHER TEIL. VON JOHANN GEORG HAGEN, S. J. ERSTE LIEFERUNG: DIE AUSRÜSTUNG DES BEOBACHTERS.[1]

Father HAGEN has evidently undertaken the preparation of a very complete work on the variable stars, for the present book—in xv + 152 quarto pages, dealing with the Observer's Equip-

[1] Freiburg im Breisgau, 1913. 4to. xv + 152 pp.

ment—forms only Part I, Volume I. The remaining parts of this volume will be three, dealing, respectively, with the Methods of Observing, the Reduction of the Observations, and the Elements of Light Variation. This will complete the discussion of the historical and technical phases of the subject. The second volume will then take up the discussion of the theories, both mathematical and physical, to account for the observed phenomena, which at present are attracting ever increasing attention.

After a brief preface, in which the author acknowledges his indebtedness to Professor MÜLLER of Potsdam, who read the proof sheets, a careful bibliography, covering seven pages, is given. In this, only separately printed books, publications of observations and transactions of academies are included. Reference is made to articles in scientific journals, only "when on account of their age or contents they have special value,"—as, for example, the catalogs of variable stars, and the meager notes on star colors.

The text proper consists of an introduction, treating (a) of the beginning and the significance of the theory of the variable stars and (b) of the various methods of observing, and of five chapters, discussing, in order, the history and literature of this new branch of science, the classification and distribution of the variables, the catalogs, nomenclature and alphabetic designations, the instruments, star charts and ephemerides, and, finally, the observing program.

The method of treatment is the historical one, copious references being made to the original papers. As all of the references have been carefully verified, the volume may be regarded, as the author says, as a source book. While the first chapter gives to ARGELANDER the credit of being the founder of this branch of astronomy, and makes special mention of his immediate colleagues and pupils, it also gives a fair account of the independent development of the subject outside of Germany, and particularly in England under POG SON and KNOTT and BAXENDALL, and brings the history down to date with an account of the increased activity of variable-star observers during the past ten years.

In the second part of this chapter emphasis is placed upon the necessity of publishing the *original data* of the observa-

tions and not merely the results. Then follow full descriptions of the various methods that have been adopted in reducing and publishing observations, reference being made to numerous publications as examples.

The classification of variable stars is very fully treated in the second chapter. New stars, missing stars, stars that have been suspected of momentary variations as well as those supposed to vary in periods of many years, are first discussed. Next follows a section on the non-periodic variables, with a discussion of what constitutes "regularity" or "irregularity" in a variable star, then a section on the periodic variables.

A full account is given of all the proposed classifications of variable stars from PIGOTT'S, in 1786, to those adopted at Harvard and in the *Viertel-jahrs-schraft* der Astronomischen Gesellschaft, with reference, also, to recent proposed classifications on a physical basis, rather than on the apparent character of the light curve. The chapter closes with a section devoted to the various published estimates of the number of variable stars, and the investigations of their distribution, as a whole, and of the various classes, with respect to the Milky Way.

This somewhat detailed account of the contents of the first two chapters will sufficiently illustrate how thoroughly the author has treated every phase of his subject.

The book will be found helpful to students and observers, both by reason of its full references to original memoirs and by reason of the author's many valuable suggestions.

The general rules laid down in the last chapter for the formation of an observing program will be found especially helpful. To form a program that is adapted to the observer's equipment, and that, when carried out, will contribute definitely to the progress of astronomy, is, as the author says, of the greatest importance. His warning as to the difficulty experienced in carrying a well-conceived program to a definite conclusion is also worth heeding. The present writer, however, regrets that the author considered it necessary to quote examples of failures in this respect.

R. G. AITKEN.

October, 1913.

## Radial Motions in Sun-Spots[1].

That the Fraunhofer lines in the outer edges of the penumbræ of sun-spots are systematically displaced was announced by Mr. Evershed in 1909, and the hypothesis was advanced that these displacements are due to the radial motion outward and tangential to the solar surfaces of the gases of the reversing layer.

The present paper gives the results of an investigation made with the spectrograph of the 60-foot tower equipment on Mount Wilson by Mr. St. John, with a view to throwing additional light upon this interesting phenomenon. For favorable observations of the displacements, the sun-spot should be located neither near the limb nor near the central meridian, and the slit of the spectrograph should be placed along the line joining the center of the spot and that of the solar disc for observing the maximum displacements.

When the spectra of the outer edges of the penumbra, directed respectively toward the limb and center of the Sun's disc are photographed side by side on the same plate, the relative displacement of the lines in the two spectra are quite marked and are such as to give, in general, a greater wave-length for the lines of the reversing layer in the edge of the penumbra on the limb side. The displacements were studied for some five hundred lines distributed in the violet, blue and yellow regions, and so chosen as to include a wide range in intensity of lines. In all, the lines given by about twenty-six elements were investigated.

The displacements are found to vary systematically with the intensity of the lines in amount and sign, and further are proportional to the wave-length for lines of the same intensity. This last fact seems to indicate clearly that the observed change in wave-length is due to the Doppler effect. If the displacements, reduced to a common wave-length, are arranged according to the intensities of the lines of any one element (iron, for example, for which he studied some two hundred lines), a remarkable series is found in which the displacements decrease systematically with increase of intensity of the lines. On the hypothesis that the displacements are due to radial velocity,

[1] *The Astrophysical Journal*, **37**, 322, 1913; *The Observatory*, **36**, 395, 1913.

they indicate an outflow of matter from spots tangential to the Sun's surface with a velocity of 1.02$^{km}$ per second for lines of intensity 00 and a velocity of 0.12$^{km}$ per second for lines of intensity 10. For lines of greater intensity the displacements reduce to zero and for the strong lines of intensity 20 to 40, as for those of sodium, magnesium, hydrogen and calcium, the displacements change sign, indicating an inflow of vapor of high levels into the spot, with velocities ranging from 0.6$^{km}$ per second to 1.89$^{km}$ per second.

In order to explain the observed connection existing between radial velocity and intensity of the lines, it is assumed as a working hypothesis "that these systematically varying displacements or velocities are due to the differences of level at which the solar lines originate" and that on the whole the weaker lines originate lower in the solar atmosphere than stronger lines. On this assumption the distribution of velocities in a vertical section of a sun-spot shows the maximum velocity of inflow at the higher levels, which decreases to zero as we descend, changes sign and reaches maximum velocity of outflow at the lowest level in which the faintest lines are assumed to have their origin. The author points out that this apparent circulation cannot be a true vortex, as the matter flowing in at the higher level is neither the same in quality nor in quantity as the matter flowing out at the lower level. The actual vortex, he believes to be much lower than the phenomenon under observation, and that the outflow into the reversing layer is the upper portion of the low-lying vortex, while the inflow from the chromosphere is merely a secondary or superficial effect of this.

While the line displacements vary regularly with the intensity of the lines of any one element, they are not equal for the lines of the same intensity of different elements. For example, the lines of titanium show a smaller positive velocity than the lines of iron of the same intensity. This is interpreted on the above hypothesis as indicating that the titanium producing a line of any given intensity is at a higher level than that in which the iron line of the same intensity originates. The series of iron lines arranged according to intensities and their corresponding displacements forms, according to the above interpretation, a sounding level for indicating the vertical distribu-

tion of the elements in the solar atmosphere. The resulting distribution found by making this comparison of the lines of different elements with those of the iron series is one in which the elements of high atomic weights occur at the low levels, while the lighter elements are found at all levels.

The author states that the interpretation of the phenomena given above "is confirmed by flash spectrum observations, and is in harmony with a wide range of solar observations in which indications of effects due to differences of level have been obtained." J. H. MOORE.

### PHOTOGRAPHS OF COMET *a* 1910.

*Lowell Observatory Bulletin*, No. 57, contains a number of excellent photographs of Comet *a* 1910, with a discussion of the plates by Mr. C. O. LAMPLAND. The usual formulæ for calculating the true position of points in the tail are collected, and modifications are derived for obtaining these values in rectangular co-ordinates as well. Of particular interest are the photographs showing the striated form of tail, of which DONATI'S comet has hitherto been almost the only example. The theory of these striæ is that a cloud of matter containing particles of slightly different size is ejected from the nucleus. Owing to the variation in size of the particles, the light action and the repulsive effect will differ, and will have the effect of drawing out the original cloud of matter into a long line. POKROWSKY has calculated the values of the repulsive force for the striæ in this comet from a photograph made by SYKORA *at* Taschkent on January 27, 1910, and has found that the repulsive action varied from $\mu = -1$ to $\mu = +0.3$.

H. D. CURTIS.

### PROPER MOTIONS OF FAINT STARS.

This important paper by Professor COMSTOCK, which has just appeared in No. 655 of the *Astronomical Journal*, is certain to give rise to considerable discussion, and cannot fail to have influence on current theories of the structure of our stellar universe. The opinion most generally accepted has been that the fainter stars, because of their presumably much greater average distance from us, have proper motions in general van-

ishingly small. It is true that the spectrographic results of the past decade, for stars extending roughly down to the sixth magnitude, have shown that, up to this point at least, the brighter and the fainter stars are much more intimately intermingled than had been hitherto supposed. But for still fainter stars the opinion has been pretty generally held that they are, relatively to the brighter stars, almost absolutely stationary as far as proper motions are concerned. This has been accepted without question and has formed the basis for a number of lines of stellar research, as, for example, the determination of stellar parallaxes, though the fact that nearly twenty-five per cent of the best modern determinations of parallax give negative parallaxes is rather disquieting.

The paper is a continuation of the work inaugurated by Professor COMSTOCK in Volume XII of the *Publications of the Washburn Observatory,* and he has now investigated the proper motions of 513 stars fainter than the eighth magnitude; of these 390 are believed to show proper motion. The accuracy of the results is discussed at length, and from the proper motions of these fainter stars a value is found for the apex of the Sun's way and for vertices of preferential drift. To quote some of the conclusions reached:—

Out of five hundred stars included between the seventh and thirteenth magnitudes, that have been observed for their proper motion, approximately seventy-five per cent yield sensible proper motions.

These proper motions confirm and extend from the brighter stars at least to the twelfth magnitude the relation that, in the mean, the amount of proper motion is inversely proportional to stellar magnitude. The relation is expressed by $\mu m = 35''$, where $m$ is the magnitude and $\mu$ the proper motion per century.

The linear velocity of stellar motions is substantially independent of stellar magnitude.

The faint stars and bright stars are parts of one and the same stellar system and are in great measure intermingled, the faint stars being less remote than has been inferred from photometric considerations.

H. D. CURTIS.

## THE PLANE GRATING FOR STELLAR SPECTROSCOPY.

Under the above title in the *Astrophysical Journal* for June, 1913, Mr. J. S. PLASKETT gives some interesting results of a comparison of the relative intensities of spectra obtained with spectrographs in which the dispersing piece is a plane grating, a silvered half-prism, one prism or three prisms.

A plane grating of 15,000 lines to the inch and estimated to diffract about 30 per cent of the incident light into one first order was mounted in a spectrograph of the usual form for comparison with the one-prism instrument of the same linear dispersion at $H\gamma$. A second spectrograph was constructed, of the Littrow type, in which either the grating or a silvered half-prism could be used, and which had a linear dispersion at $H\gamma$ equal to that of the Dominion three-prism.

A comparison of the relative intensities of the spectra photographed with these several instruments was obtained in the usual way from successive exposures of different lengths on the same celestial objects. The general results of this comparison are briefly the following:—

First, the marked superiority of grating over prismatic spectra in the uniformity of intensity from $H\beta$ to $\lambda$ 3850.

Second, that in relative intensity of the spectra the three-prism has the advantage over the grating from $H\beta$ to $\lambda$ 4300, while for the region to the violet of $\lambda$ 4300 the advantage is with the grating.

Third, that single or half-prism spectra are more intense than those of the grating from $H\beta$ to the K line.

The lack of uniformity in intensity of prism spectra and their inferiority in intensity in the violet region as compared with grating spectra is due, as is well known, to the rapid increase in dispersion and absorption of a glass prism in the region of short wave-lengths.

A grating may therefore be used to advantage in stellar spectrographs for studies in the region of the K line and farther to the violet, or where uniformity of intensity or dispersion is required. From the results here given, it appears that if a grating were ruled giving twice the intensity of the one used in the present experiments, it would be superior to single-prism dispersion for most work. J. H. MOORE.

## Bond Zones of Faint Equatorial Stars.

The 15-inch east equatorial of the Harvard College Observatory was for many years the most powerful telescope in this country and had but one equal in Europe—the 15-inch equatorial at Pulkowa. One of the large pieces of work accomplished with this instrument in the years 1852 to 1860 was the observation of the faint stars in the zone from the equator to 1° north declination. The results were published in *Harvard Annals,* I Pt. II, II Pt. II, and VI, and are now brought together in a single catalog on a homogeneous system. The work was carried out by Miss Margaret Harwood, assisted by Miss Mary O'Reilly, under the direction of Professor Pickering, and the catalog forms Volume LXXV, Part I, of the *Annals.*

The Nicolajew catalog of the Astronomische Gesellschaft contains the positions of 1,756 stars that are also included in the Bond Zones. These furnished the data necessary to reduce the Bond places to the Nicolajew system, an ingenious graphical method being employed to find the corrections. As, in general, each zone was observed twice, usually on consecutive nights, the data were also available for detecting errors of various kinds, and for estimating the probable error of a star-place. This is found to be, for a star observed in two zones, $\pm 0^s.06$ in right ascension and $\pm 0^s.6$ in declination.

The average magnitude of the stars is below 11, and stars as faint as 13 and 13.5 are to be found in the catalog. The chief value of the catalog is that it affords "almost the only material now available for determining from visual observations the proper motions of the faint stars."

R. G. Aitken.

October, 1913.

## A Catalogue of 16,300 Stars Observed with the 12-Inch Meridian Photometer—E. C. Pickering.

The record of the extensive photometric observations made at the Harvard College Observatory is continued in Volume LXXIV of the *Annals,* which contains the results of Professor Pickering's own measures with the 12-inch meridian photo-

meter on stars other than those in the Durchmusterung Zones published in *Harvard Annals,* **70**.

The stars may be divided into classes showing the reasons for their selection:—sequences for variable stars, stars from the Bond Zones (referred to in another note in this number of the *Publications*), stars from KAPTEYN's Selected Areas, comparison stars for Halley's Comet, for *Eros* and other asteroids, etc,—in all twenty-five different classes of stars. The great majority are faint, ranging from magnitude 9.0 to 13.5.

The volume, in its arrangement of results, shows the thought that has been bestowed upon the question of compressing a vast amount of information into small compass and in convenient form for use. This problem has been very successfully solved without the slightest detriment to the value of the work.

Professor PICKERING's own measures with this photometer have now reached the total of 726,952.

R. G. AITKEN.

October, 1913.

## DISTRIBUTION OF THE STARS IN DISTANCE FROM THE SUN.

Two articles have recently appeared in the *Monthly Notices,* **73,** 334, 346, upon the distribution of stars in space, or the numbers of stars at various distances from the Sun. In one, DYSON says: If the law of distribution of linear velocities of stars be known, it should be possible by comparison with proper motions to derive the law of distribution of stellar distances. In the other, EDDINGTON says: The problem is to find how the stars are distributed in distance from the Sun.

Two assumptions are made: First that the same law of occurrence of linear velocities holds throughout space; second, that the components of velocity across the line of star-streaming occur according to the law of errors. The first assumption eliminates any relation between the velocities and intrinsic luminosities. The second is well corroborated by observation, as is shown by the following figures derived from the Lick Observatory radial velocities of Class K stars: For velocities between $0^{km}$ and $5^{km}$, the law of errors requires 53 stars, while 55 were observed; between $5^{km}$ and $10^{km}$ are found by the law 46, by observation 47; between $10^{km}$ and $15^{km}$ by the law 38, by observation 30; between $15^{km}$ and $25^{km}$ by the law 27, by obser-

vation 30; between $25^{km}$ and $40^{km}$ by the law 6, by observation 10; greater than $40^{km}$, by the law none, and by observation none. This is one way of showing that observed radial velocities confirm the phenomena of star-streaming.

It is next assumed that the number or proportion of stars at a distance $r$ is an exponential function of $r$ of the form—

$$r \cdot e^{-h^2r^2}$$

in which $h$ is a constant. By comparison with the proper motions of CARRINGTON's circumpolar stars and of the Boss stars brighter than sixth magnitude, values of the constant have been found which best fit the observations. The function then forms the basis for calculating the number or proportion of stars at various distances, the unit of distance being that corresponding to a parallax of one second of arc. DYSON finds in his discussion of the CARRINGTON circumpolar stars that more than one third of them are congregated between 200 and 400 units of distance or between 600 and 1,200 light-years, and that practically none are beyond a 1,000 units or 3,200 light-years, while only one may be nearer than 40 units or 130 light-years. EDDINGTON, in discussing the stars brighter than sixth magnitude in Boss's Catalogue, has separated the Class A and Class K stars and has divided each class into high and low galactic latitudes. He finds for all these stars in general that between one third and one half of them are congregated between 50 and 100 units of distance or between 160 and 325 light-years. He remarks in discussion of the results that it is not easy to say how reliable they may be, but they indicate one method of attacking the problem. The comparatively small range of distance which includes the great majority of the stars is a noticeable feature. Professor KAPTEYN's numbers correspond to a distribution considerably more spread out. The present numbers appear to record well with the usual views of stellar distribution; namely, that near the Sun the density of stars is fairly uniform, and that in the plane of the galaxy this uniform distribution extends a great distance, while perpendicular to the plane, the density thins out rather rapidly.

From the results of these discussions of stellar distances, DYSON and EDDINGTON have derived the numbers of stars of

various luminosities contained within a sphere of radius corresponding to a parallax of one one-hundredth of a second of arc or 325 light-years. DYSON's figures are 23,000 stars brighter than the Sun, 5,000 more than 10 times the Sun, 1,500 more than 25 times the Sun, 300 more than 50 times the Sun, 24 more than 100 times the Sun, and none more than 200 times the Sun. He concludes that 95 per cent of the CARRINGTON stars are brighter than the Sun and beyond the sphere of 0''.01 of parallax. EDDINGTON's figures, based on the stars of Boss's Catalogue, are for Class K stars only: namely, 2,700 stars between one and 10 times as bright as the Sun, 1,000 between 10 and 100 times the Sun, 100 between 100 and 500 times the Sun, 10 more than 500 times as bright as the Sun, or a total of more than 3,700 stars brighter than the Sun.

G. F. PADDOCK.

October, 1913.